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Recent and potential future effects of climate change on snow-avalanche activity in western Norway

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Meteorological records for western Norway show the general trend that the last 100 years, and especially the last three decades, have been warmer and wetter than the time periods before. As snow-avalanche formation is mainly governed by meteorological conditions as, e.g., air temperature fluctuations, heavy precipitation and wind conditions, it is likely that the frequency and magnitude of both ordinary and extreme snow-avalanche events is and will be modified through the documented effects of current and future climate change.

This work focuses on recent and possible future effects of climate change on snow-avalanche activity along the western side of the Jostedalsbreen ice cap representing one of the areas with the highest snow-avalanche activity in entire Norway. We have analyzed long-term homogenized meteorological data from five meteorological stations in different elevations above sea level, three of them with a long-term record of 120 years (1895-2015). Daily precipitation and air temperature data are analyzed from the highest situated meteorological station (located 872 m asl.) in order to reveal the percentage share of precipitation which occurs actually as snow within the snow avalanche source areas (generally located at this and higher elevations above sea level). In addition to the statistical analyses of long-term datasets, gained results and insights from a four-year (2009-2012) high-resolution snow avalanche monitoring study conducted in the same study area are incorporated. The statistical analyses of mean monthly air temperature, monthly precipitation sums and mean monthly snow depths showed that there is a trend of increasing air temperatures and precipitation sums whereas no clear trend was found for mean snow depths. Magnitude-frequency analyses conducted for three defined time intervals (120, 90, 60 years) of monthly precipitation sums exhibit an increase of precipitation especially during the last 30 years with the tendency that more precipitation is occurring in February and March. Results from the four-year monitoring study detected that the current main snow avalanche peak season occurs between March and May. In addition, a high statistical correlation (R2 = 0.8) between the total amount of snow accumulated over the winter months and the total number of snow avalanches occurring in spring was found.

While strong winds, rapid air temperature fluctuations and heavy snow fall events are identified as the main triggering mechanism for snow avalanches along the SW coast of Norway, an increase of the monthly precipitation sums (snow fall) during the winter period may lead to a generally higher snow-avalanche frequency. The detected trend of increasing air temperatures might not necessarily affect the current and near future snow-avalanche activity as snow avalanches are triggered in higher elevations above sea level where precipitation will still occur as snow fall. However, it is possible that the current snow avalanche peak season might shift forwards, starting already in February.